Lung Compliance

ILOs: By the end of this lecture the student will be able to:

1. Outline the elastic properties of the lung.
2. Define lung compliance and mention its normal value.
3. Describe the curve of the lung compliance.
4. List the factors affecting lung compliance.
5. Define the work of breathing & name the conditions that increase it.

Elastic properties of the lungs

The lungs expand during inspiration and recoil during expiration. The ability of the lungs to stretch and to return back to their original position when the stretching forces are removed can be explained by two important interrelated concepts: **compliance and elastic recoil.**

I. Lung compliance

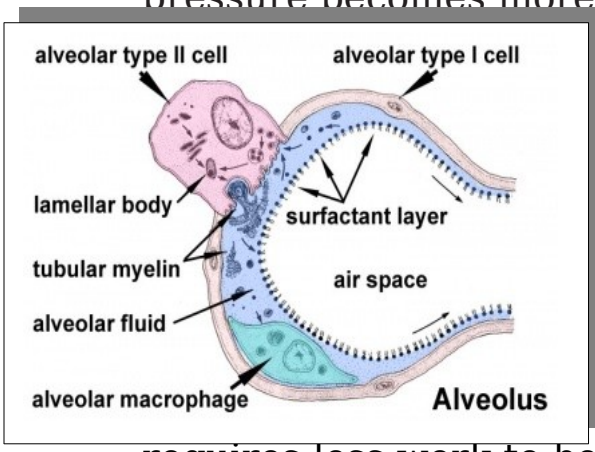
Lung compliance is change in lung volume **(ΔV)** per unit change in transpulmonary pressure gradient (**ΔP**) (i.e., distending pressure). This is stated in the following formula:

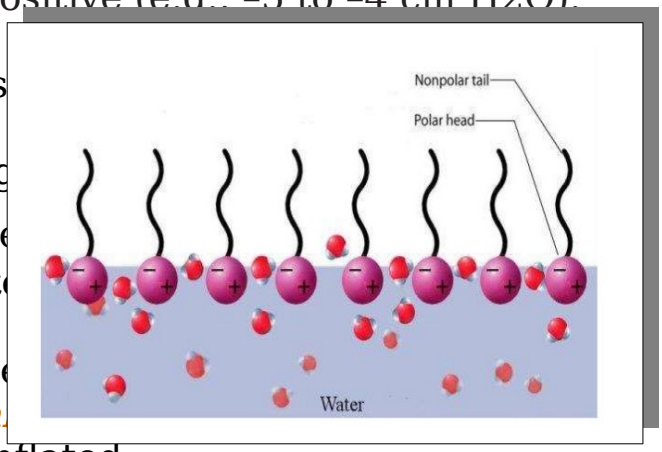
$$\text{Compliance} = \frac{\Delta V}{\text{---------}}$$

Example:
Tidal volume = 0.6 liters
Intrapleural pressure before inspiration = –5 cm H2O
Intrapleural pressure after inspiration = –8 cm H2O

$$\text{Lung compliance} = \frac{6 \text{ liters}}{3 \text{ cm H20}} = 0.200 \text{ liters/cm H2O}$$

- The preceding calculation simply means that for every 1 cm H2O surrounding pressure changes, 200 mL of air flows in or out of the respiratory system. It flows into the system if surrounding pressure becomes more negative (e.g., –5 to –6 cm H2O) or out of the system if surrounding pressure becomes more positive (e.g., –5 to –4 cm H2O).

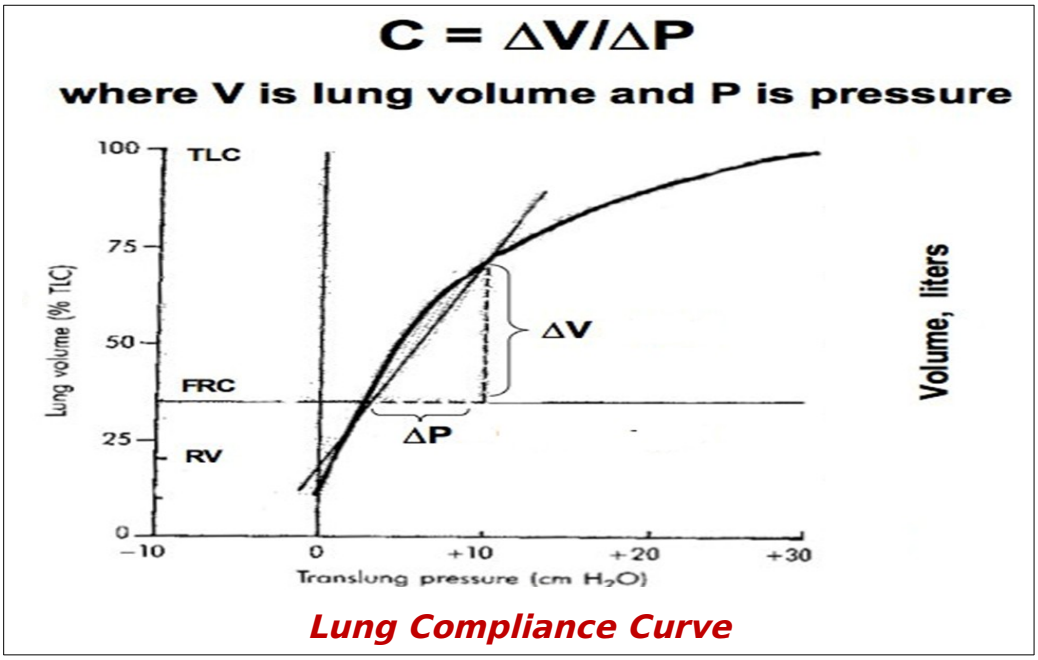




requires less work to be inflated.

- **The compliance of the chest wall:** is the change in lung volume **(△V)** per unit change in ***trans-thoracic*** pressure **(△P).**
- Compliance of the lungs and chest wall together is 0.1 L/cm H_2O transmural pressure (less than that of the lungs alone), because lung distensibility in chest is limited by the rigid thoracic wall. This means that the combined lung-thorax system is less compliant than the lung alone.

  Lung inflation curve:



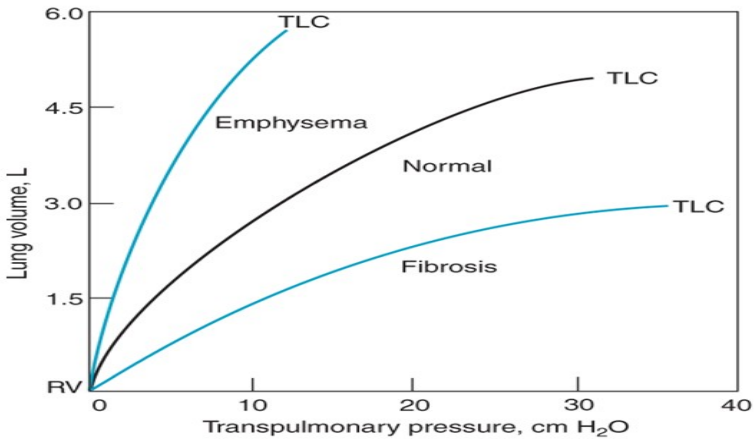
Lung Compliance Curve

- In the preceding curve, a relationship between the change in lung volume (tidal volume) and the change in intrapleural or surrounding pressure is shown.

- The steeper the line, the more compliant the lungs. Restful breathing works on the steepest, most compliant part of the curve.
- With a deep inspiration, the lung moves toward the flatter part of the curve, and thus it has reduced compliance. Lung compliance is less at TLC.

Importance of lung compliance:

- It is a measure of distensibility or expandability of the lungs (or how easy the lung is stretched).
  - A lung which expand easily has a high compliance
  - A lung with increased elasticity (elastic recoil) is harder to inflate
  - ***Thus, compliance is the inverse of elasticity***.



Factors Affecting Pulmonary Compliance

Factors affecting lung compliance:

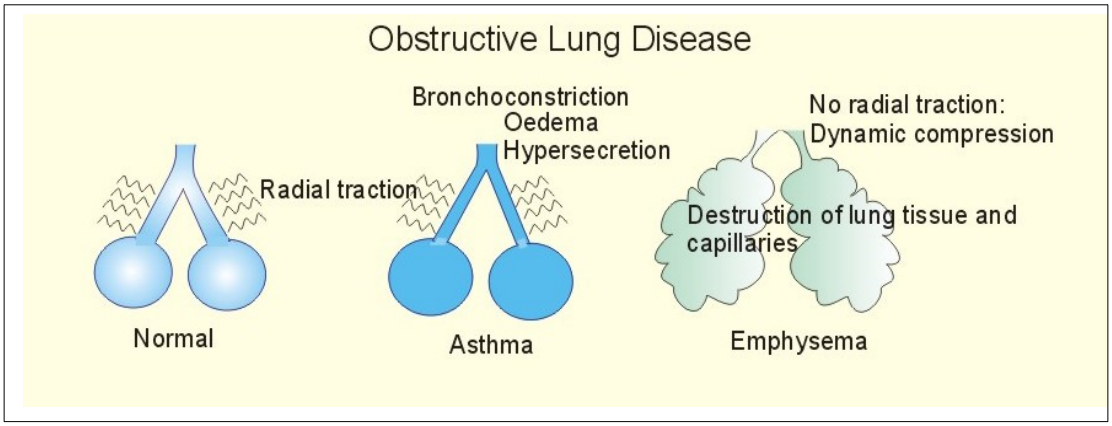
I. Increased compliance means more air will flow for a given change in pressure. i.e less pressure is needed to inflate this lung, **Compliance is increased in:**

1. Elderly: due to loss of lung elastic tissue with a resulting decrease in elastic recoil of the lung.
2. Emphysema: due to destruction of alveolar walls with reduction of tissue elastic forces.

II. Reduced compliance means less air will flow for a given change in pressure. i.e more pressure is needed to inflate the lungs.

Compliance is decreased in:

- Pulmonary congestion and edema.
- Pulmonary fibrosis.
- Respiratory distress syndrome.
- Persons with only one lung (pneumonectomy).



Note:

In loss of lung elastic tissue (e.g emphysema), there is a great difficulty in expiration due to:

1. ↓↓ elastic lateral traction → collapse (closure) of small airways → ↑↑ airway resistance.
2. ↓↓ elastic recoil makes passive expiration not enough to empty the lungs, so abdominal muscles contract at rest (active expiration) → ↑↑ the work of breathing

III. Elastic recoil forces (Elastance)

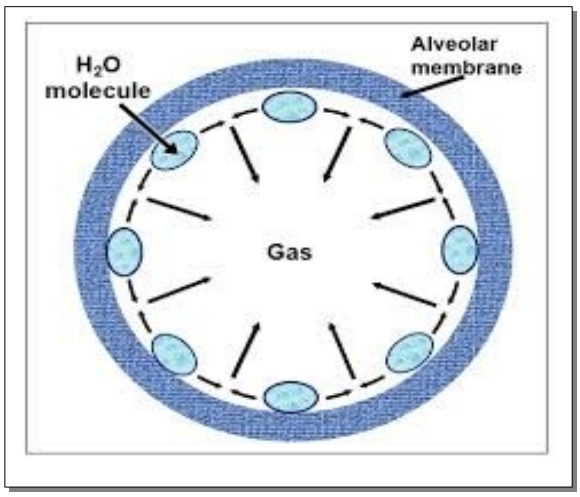
It refers to how the lungs rebound after being stretched. i.e a lung with increased elasticity (elastic recoil) is harder to inflate.

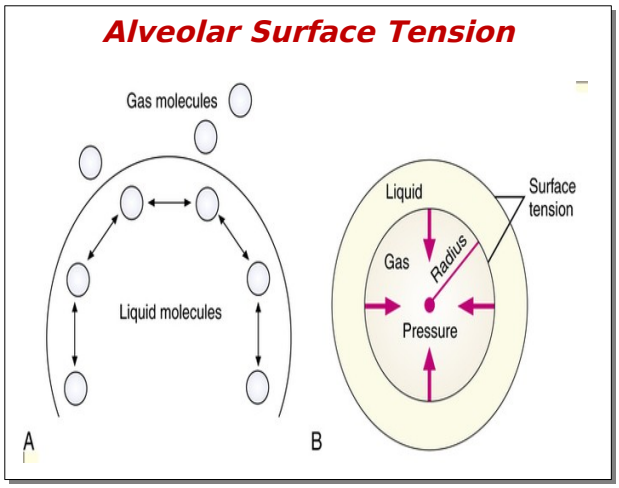
Lung recoil has the following components:

1. **Elastic forces of the elastic tissue in the lungs (Lung elasticity):** It is caused by the elastin and collagen fibers present throughout the lung tissues.
   - Both lungs and thoracic wall contain elastic tissue. So, they distend, and once the distending force is released, they recoil back.
   - They represent 1/3 of the total elastic forces.
2. **The surface tension forces in the fluid lining the alveoli:** Surface tension forces are created whenever there is a liquid–air interface. Surface tension forces are produced by the attractive forces between the water molecules at the surface of the liquid film that lines the alveoli, which make alveoli resist inflation and become less in size (act to collapse the alveoli). Thus, these forces contribute to lung recoil.
   - They represent 2/3 of total elastic forces.

Therefore, lung expansion requires energy to:

a. stretch the elastic tissue of the lungs
b. overcome the surface tension force of the fluid layer lining the alveoli overcome the surface tension force of the fluid layer lining the alveoli.





Work of Breathing

It is the work performed by cles during breathing.

- During normal quiet breathing, inspiration is active and work is done by the inspiratory muscles. Expiration is passive, as it is done by elastic recoil of the lungs and thoracic wall. So, no work is performed.

- **Normally, the lungs are highly compliant and airway resistance is low.**
  Therefore, the work of breathing constitutes:
  - Only 3% of total energy expenditure during quiet breathing.
  - Only 5% of the total energy expenditure during strenuous exercise.
- However, in patients with poorly compliant lungs or obstructive lung disease, the work of breathing will be about 30% of the total energy expenditure, even at rest.
- **There are 2 types of work:**

1- Elastic (compliance) work (65%):
It is the work done to expand the lung against elastic tissue forces & alveolar surface tension forces.

2- Non elastic (resistive) work (35%):
It is the work done to overcome air way resistance & tissue resistance.

- Tissue resistance represents 20% of the resistive work and is caused by the friction produces as the lung tissues move against each other as the lung expands.
- Airway resistance represents 80% of the resistive work.

- **The work of breathing is increased in:**
  a. Decreased lung compliance (e,g in lung fibrosis and RDS).
  b. Increased airway resistance (e.g. COPD).
  c. Increased ventilation (e.g. during exercise).
  d. Decreased elastic recoil (e.g. emphysema).
  e. Increased tissue resistance (e.g. sarcoidosis).